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Is an Accessible Website a More Usable One?

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Abstract

The effect of the World Wide Web is noticeable in organizations, businesses, societies, and individuals. When websites are evaluated, two important website qualities are examined, accessibility and usability. E-accessibility is "a measure of the extent to which a product or service can be used by a person with a disability as effectively as it can be used by a person without that disability for purposes of accessing or using ICT related products or services" (Qatar's e-Accessibility Policy, 2011). Several studies have explored the accessibility status of websites and studied the effect of accessible websites on users, especially users with special needs. Many tools have been developed to automatically assess accessibility. It remains difficult to convince organizations to make their websites accessible. The author was motivated to explore if accessibility makes websites more usable. If such claim turns out to be true, it will become economically persuasive to convince website owners to invest in accessibility. I present a framework to study the impact of website accessibility on its usability through a five-stage methodology. A total of seven tools were selected to be used to assess both accessibility and usability. Then, a framework was produced to act as a single tool for website usability measurement.

Introduction

Overview of e-Accessibility

Information technology has impacted our lives in many different ways. Its effects are noticeable in organizations, businesses, societies, and individuals. In the educational sector specifically, the World Wide Web (Web) has an integral role in delivering and serving students, faculty, and staff through websites. Many of these websites do not deliver information in an accessible way that satisfies people with disabilities. In their research on the admission process at colleges, Erickson et al. (2013) found that "Over half of the users found the online admissions application process frustrating" (Erickson et al., 2013). Educational organizations have a social responsibility to serve students and faculty with disabilities and provide them with the same level/standard of education as abled people. According to Lazzaro, around 750 million people in the world suffer from physical, cognitive, or sensory disabilities (Lazzaro, 2001). This number is increasing through time as is the usage of information and communication technology (ICT).

E-accessibility is "a measure of the extent to which a product or service can be used by a person with a disability as effectively as it can be used by a person without that disability for purposes of accessing or using ICT related products or services" (Qatar's e-Accessibility Policy, 2011).

In Qatar, people are increasingly relying on ICT in their everyday lives; this is shown in the International Telecommunication Union's ICT Development Index 2013, which ranked Qatar 31th out of 157 countries in terms of the level of ICT access and usage (ITU, 2013). Efforts are being made to cater to disabled people's needs and to provide accessible Information and communication technologies. However, technology services, specially the Web, remain inaccessible to persons with disabilities, including the elderly (MADA website, 2013). Because millions of people have disabilities, inaccessible ICT services will exclude them from using advanced technologies.

Organizations should consider catering to this group of people through providing an accessible means of communication between an organization and its audience. Making a website more flexible and accessible will result in more users coming to the organization's website. This will not only benefit abled users, but organizations will also benefit from search engine optimization (SEO) and increased customer loyalty.

It remains difficult to persuade websites owners to make their sites accessible. However, making websites usable is sought after because it increases the acceptance of the users. The author was motivated to explore if accessibility makes websites more usable? If such claim turns out to be true, it will become economically persuasive to website owners to invest in accessibility. In this research I develop a methodology to allow us to investigate the relationship between website accessibility and usability.

Chapter 1 synthesizes what the literature says about the e-accessibility topic. The literature review is divided into four sections: Web Accessibility, Web Accessibility Standards, Web Usability, and Web Usability Standards.

Chapter 2 presents a five-stage research methodology that allows us a choice of the domain to study and to find ways to assess accessibility and usability and combine them into a unified framework that can be used in multiple contexts and calculate the correlations between accessibility and usability.

Chapter 3 presents our main contribution, a framework for the assessment of usability and e-accessibility.

Chapter 4 presents our conclusions and future work.

Chapter 1: Literature Review

Section 1: Web Accessibility

Web Accessibility

There is a growing worldwide recognition of disabled people's right to access technology, specifically the Web. It has resulted in many policies and laws that ensure Web accessibility for all users. The World Wide Web Consortium (W3C) is an international association that develops guidelines, specifications, and standards for the Web (W3C website, 1997). The W3C founded the Web Accessibility Initiative (WAI), which develops guidelines and references to make the Web accessible (W3C website, 1997). According to WAI, "Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web" (Henry, 2005). The latter definition includes all types of disabilities (e.g., physical, visual, hearing, and speech) and applies to various Web technology (e.g., websites, browsers, and media players).

Section 2: Web Accessibility Standards

Governments, institutions, and organizations are working to adapt Web content so that it becomes usable by everyone in a society (abled-bodied and disabled people). The European Commission has initiated e-accessibility promotions to ensure accessibility by the disabled on an equal basis with others. Nowadays there are standards that govern website e-accessibility. Such standards are not uniform across countries, and they vary in terms of completion.

International Standards

The WAI, which is a part of W3C, created the first version of Web Content Accessibility Guidelines (WCAG 1.0). This version was updated to WCAG 2.0, and it has been used as the official standard since 2008. WCAG 2.0 added four new principles to the standard and some

modifications were made to the guidelines. Through these four principles, the WCAG 2.0 standard assures that disabled people can navigate the Web by using assistive technologies. Bradbard and Peters (2010) produced a table that shows changes and compares the WCAG 1.0 and WCAG 2.0 standards (see Table 1).

Table 1: WCAG 1.0 and WCAG 2.0 Comparison

WCAG 1.0	WCAG 2.0
	4 Principles
14 Guidelines	12 Guidelines
67 Checkpoints	61 Success Criteria
3 Priority Levels per Checkpoint	3 Levels per Success Criterion
3 Levels of Conformance	5 Requirements for Conformance

Qatar Standards

The legal framework for Web accessibility varies across countries. Some countries developed guidelines, and others require some level of accessibility, at least in the education and government sectors. Qatar released in 2011 a National e-Accessibility Policy that aims to raise the e-accessibility level across digital platforms. Part of the policy was establishing MADA (Qatar Assistive Technology Center), a nonprofit organization established by the Supreme Council of Information and Communication Technology (ICT Qatar) (MADA website, 2013). Its e-accessibility services are provided to make Qatar's digital content accessible by all (MADA website, 2013). The policy states that Web Content Accessibility Guidelines (WCAG) 2.0 should be followed by all websites in Qatar, and these are the standards used by MADA to achieve accessibility in Qatar.

In addition to WCAG 2.0, MADA has developed a basic website accessibility checklist specifically for Qatar. Because the research in this thesis focuses on Qatar, the test websites will be assessed against this MADA checklist to determine its compliance with Qatar's policy. The checklist considers content in Arabic Language, and it could be adopted by organizations to assess and achieve accessibility (Park, 2012).

Section 3: Web Usability

The International Organization for Standardization (ISO) is the world's largest developer of standards for products, services, and best practices. Since 1947, the ISO has developed and published "19,500 international standards covering almost all aspects of technology" (IOS website).

In (ISO 9241-11, 1998) the term "usability" is defined as: "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO 9241-11, 1998).

According to ISO/IEC 9126 (1991), usability is "a set of attributes" that collectively assess the usability of a product/website.

The Institute of Electrical and Electronics Engineers (IEEE) also defines usability in its Standard Glossary of Software Engineering Terminology as "the ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component" (IEEE, 1990).

Jakob Nielsen is a usability consultant and user advocate and principal of Nielsen Norman Group (Evidence-Based User Experience Research, Training, and Consulting). In 2000, Nielsen published *Designing Web Usability*, which included standards for website usability (Nielsen, 2000). Nielsen defines usability as "a quality attribute that assesses how easy user interfaces are to use" (Nielsen, 2003).

Section 4: Web Usability Standards and Guidelines

Many governments and organizations have been involved in the effort to develop comprehensive usability guidelines. Each set of guidelines has some strong points. However, no single inclusive set of usability guidelines is followed internationally. The most prominent guidelines in usability assessment are ISO 9241-11 (1998) (ISO 9241-11, 1998) and Health and Human Services (HHS) (U.S. Department of Health and Human Services, 2006).

ISO Standards

ISO 9241-11 (1998):

> ISO 9241-11 is the Guidance on Usability developed by the ISO, and it includes an explanation of information needed when specifying usability. This information is in terms of effectiveness, efficiency, and user satisfaction, which are the major attributes of the usability of a product. (ISO 9241-11, 1998)

ISO 9241-151 (2008):

> ISO 9241-151 provides guidance on the human-centered design of software Web user interfaces with the aim of increasing usability. (IOS 9241-151, 2008)

HHS (U.S. Department of Health and Human Services, 2006):

> In 2004, the National Cancer Institute, part of the U.S. Department of Health and Human Services (HHS), developed Web Design and Usability Guidelines. The guidelines are based on extensive research on how users interact with websites. It originally consisted of 187 guidelines, but revisions in 2006 raised the total number to 207.

The HHS guidelines cover many issues on the Web, such as accessibility, Web design, navigation, graphics and multimedia, content organization, and user experience. Of the 207 guidelines, 39 fall in the usability category.

Each of the guidelines consists of:

1- A title, which is a brief statement of instruction;

2- Comments and further explanation of the guideline;

3- Sources from which a guideline was initiated or recommended;

4- Two ratings:

   a. Relative Importance: This is an evaluation based on the question, "How important is this guideline to the success of a Web site?", Sixteen reviewers (8 website designers and 8 usability specialists) evaluate the importance of the guideline on a scale of 1-5.

   b. Strength of evidence: A group of eight usability researchers, practitioners, and authors were recruited to generate a "Strength of Evidence" rating for each guideline.

Universal Design

Web designers should design the Web to be used by most members of the target audience, regardless of their abilities and ways of interacting with the Web. Universal design (UD) is "The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Connell, Jones, Mace, Mueller, Mullick, Ostroff, Sanford, Steinfeld, Story, & Vanderheiden, 1997).

In the context of the Web, accessibility is similar to UD because both concepts are trying to achieve barrier-free designs for all users. Almeida and Baranauskas (2010) conducted a study of the fine line between UD and Web accessibility through a case study that combined both

concepts. The paper identified the difference between UD and accessibility. Then it provided a proposal combining both WCAG accessibility guidelines and UD principles so that Web designers overcome the barriers found in the authoring of Web-based systems (Amedia & Baranauskas, 2010). To evaluate their proposal, the authors conducted a case study that evaluated two Brazilian governmental websites by using a combined set of guidelines and principles that covers more evaluation aspects.

The combination process mapped each UD principle with WCAG guidelines to show where the content shared common characteristics. For example, UD principle 3.4 “Arrange information consistent with its importance” was mapped with WCAG criteria “2.4.10 Section headings” (Amedia & Baranauskas, 2010). This mapping addresses the same specific theme of grouping similar content.

The paper then presented a case study that involved 20 subjects (17 students and 3 accessibility specialists) to evaluate the two websites in FAware (“a framework that aims at supporting design of awareness mechanism for Web-based design that is based on UD principles”(Amedia & Baranauskas, 2010)).

The paper presented a good strategy for comparing and combining similar concepts. The idea of finding common “themes” in each evaluation concept provides more perspective for approaching and improving an issue such as Web accessibility. Such a proposal could be implemented to compare WCAG accessibility guidelines with other Web qualities such as design heuristics and usability guidelines.

Research Significance

This research focuses on understanding whether a website's accessibility level can affect its usability level. To help in developing this understanding, a framework that combines different usability measures will be created to act as a single tool for usability assessment and evaluation.

Chapter 2: Methodology and research design

Research Methodology Description

The purpose of this research is to explore whether accessible websites are more usable not only by disabled people, but also by fully abled people. This chapter will explain how this question will be approached in this research. The methodology is divided into five stages (see Diagram 1). These stages will be followed to support the hypothesis of the research.

Diagram 1: Research Methodolgy Stages

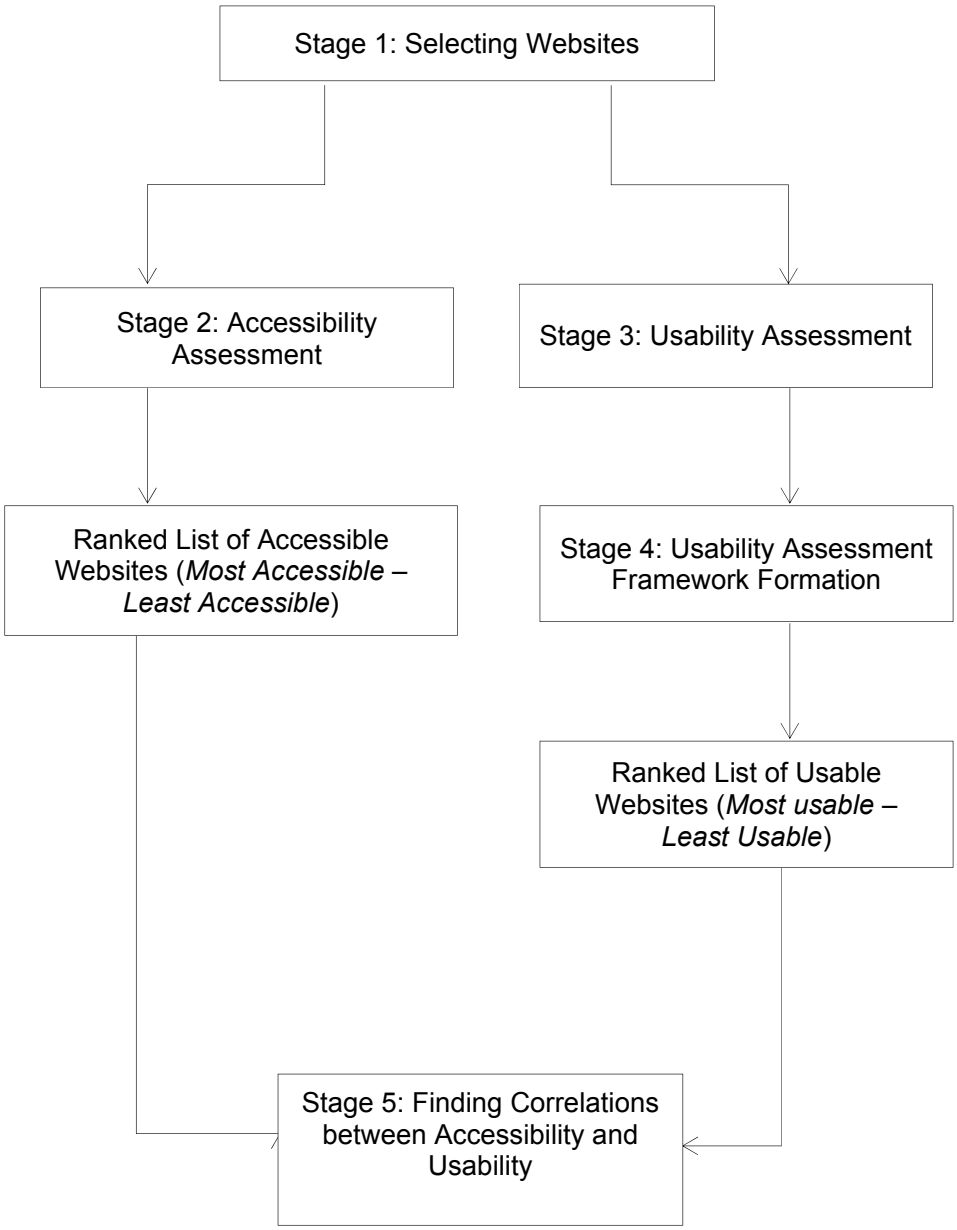

Diagram 1: Research Methodology

Stage 1: Selecting Websites

A domain can be chosen to correlate e-accessibility with usability. To illustrate our intent in this stage, let's take an example. Say that 25 websites can be chosen to assess their accessibility and usability status. These 25 websites could represent a mix of Qatar universities' websites, colleges' websites, educational centers' websites, and schools' websites (international schools) in Qatar. These websites could serve the same purpose of delivering information and communicating with the same types of users, which are students, faculty, and staff.

Stage 2: Web Accessibility Assessment

There are various services and software tools that could help websites designers and developers to evaluate the accessibility of a website and whether it conforms to the various accessibility guidelines. Most of these tools are automated so that when the website URL is entered, they automatically check the page and its conformance to the guidelines. Some tools also provide recommendations and feedback on how to fix problems.

When selecting which assessment tool(s) to use, two very important factors should be considered: the Web accessibility guidelines used and the guidelines' principles. Which accessibility guidelines are supported is a very important quality to know, because different tools use different guidelines (e.g., WCAG 1.0, WCAG 2.0, or Section 508 guidelines). The important quality is which part of the guidelines/principles a tool covers. Some tools provide a checklist and an overall assessment for every guideline, but other tools provide feedback and assessment on one part of the guidelines (e.g., color contrast or text-alt presence for nontext content).

To determine a website's accessibility status, an assessment of its components and elements should be conducted. These elements are presented in Table 2 below (Caldwell, 2006).

Table 2: Accessibility Checklist for Web Content Accessibility Guidelines 2.0 (WCAG 2.0)

Guideline Element	Accessibility Concern
Formatting	Gives Web pages, word documents, and presentations structure (page title, headings, lists).
Navigation	Build your site so that it can be navigated using a keyboard or through the use of assistive technology.
	Establish consistent navigation throughout the site or course.
Graphics (That are important to page content)	Include alt tags and/or long descriptions (if the graphic element provides detailed information).
Graphics (That are purely aesthetic)	Include a "blank" alt tag so that the screen reader does not read the image name.
Video clips	Include captions for students who are deaf or hard of hearing and preferably a script of video for students who are blind or have low vision.
Audio clips	Include a link to transcripts of any audio clips that you use.
Tables for layout	Make sure a screen reader will read the table in an order that makes sense to the user. Use a validation tool that will show you the order that the cells will be read by a screen reader.
Tables for data	So that the relationship of data cells to each other is clear to students accessing the site with a screen reader, data cells must be associated with header cells.
Color and Contrast	Make sure text is on a background with good contrast.
Flashing/ flickering objects	Flickering objects Avoid flashing and flickering graphics and text. Flickering items trigger seizures in people who have seizure disorders.
Related links	Make sure the sites that you recommend to students are accessible or be prepared to provide the content in an alternate format.

In this research, two automated assessment tools were used to evaluate websites' accessibility: Web Accessibility Versatile Evaluator (WAVE) and Colour Contrast Analyzer. These tools are used by MADA when reviewing and auditing a website.

- WAVE (WebAIM, n.d.): WAVE is a tool developed by WebAIM that is used to analyze WACG 2.0 compliancy. WAVE is available both online and as a Firefox add-on. WAVE provides accessibility feedback and recommendations only on one page. It shows indicator icons on the original Web page, and the icons can be clicked to show the accessibility violations/information on a specific element. WAVE also provides the total number of errors and warnings found in a page.
- Colour Contrast Analyzer Software (The Paciello group, n.d.): This software can be downloaded and used to calculate the color contrast and visibility between foreground and background combinations. The analyzer gives a pass/fail valuation of compliance with the WCAG 2.0 color contrast ratio (minimum ratio of foreground to background color is 4.5:1).

At the end of this stage, each website will be evaluated using the tools discussed above and ranked according to number of accessibility errors it receives. Then all 25 websites will be combined in a ranked list, from most accessible to least accessible.

Stage 3: Web Usability Assessment

Unlike accessibility, no one tool assesses the usability status of a website. There are many models and methods that try to evaluate usability by using quality attributes and/or characteristics. However, , each approach differs in the way usability is defined. Seffah, Donyaee, and Kline have proposed a QUIM model (Quality in Use Integrated Measurement) in which various models and measurements are combined into one single usability measurement. "The main application for QUIM at this time is to provide a consistent framework and repository for

usability factor, criteria, and metrics for educational and research purposes" (Seffah, Donyaee, & Klein, 2006). The QUIM model decomposes usability into 10 factors and 26 criteria as presented in Table 3 below.

Table 3: Usability Factors and Criterias in QUIM

	Factors									
Criteria	**Efficiency**	**Effectiveness**	**Satisfaction**	**Productivity**	**Learnability**	**Safety**	**Trustfulness**	**Accessibility**	**Universality**	**Usefulness**
Time behavior	+			+						
Resource utilization	+			+						+
Attractiveness			+						+	
Likeability			+							
Flexibility		+	+					+	+	+
Minimal action	+		+		+			+		
Minimal memory load	+		+		+			+	+	+
Operability	+		+				+	+		+
User guidance			+		+			+	+	
Consistency		+			+	+		+	+	
Self-descriptiveness					+		+	+	+	
Feedback	+	+							+	+
Accuracy		+				+				+
Completeness		+				+				
Fault-tolerance						+	+			+
Resource safety						+				
Readability								+	+	
Controllability							+	+	+	+
Navigability	+	+					+	+	+	
Simplicity					+			+	+	
Privacy							+		+	+
Security						+	+			+
Insurance						+	+			
Familiarity					+		+			
Loading Time	+			+					+	+

For each relationship between a factor and a criterion, a usability assessment tool is used to evaluate that specific aspect/combination. Google search was used to choose four tools for this task based on their capability to measure and assess factors and criteria of the QUIM model.

- GTmetrix (Gossamer Threads, n.d.): Measures website performance and speed
- Feedback Army (Feedback Army, n.d.): This tool assesses website familiarity, learnability, and flexibility
- WAVE (WebAIM, n.d.)
- Colour Contrast Analyzer (The Paciello group, n.d.)

Some of these tools, such as GTmetrix, provide quantitative assessments to analyze the performance of the website in terms of the number of seconds it takes a page to load. Other tools result in qualitative feedback. For example, when assessing users' satisfaction, a tool like Feedback Army will reflect users' thoughts about how they perceive a website. All of the evaluations and feedback provided by these tools will be combined to form a single measurement framework.

Stage 4: Framework Formation

There are different factors and criteria affecting website usability and each has its own evaluation tools. However, we found out that there is no consistent way to provide one measure of the usability status of a website. A framework that combines and measures all usability factors and criteria is needed to clearly explain a website's usability level. This stage will analyze the results of the different tools, develop calculations and algorithms, and finally provide one score that describes a website's overall usability level.

The developed framework will be used to evaluate each of the 25 websites and to produce a rankings from most to least usable based on a unified score.

Stage 5: Accessibility and Usability Correlation

The final stage of this research will be to find how the accessibility of a website affects its usability. The hypothesis we want to test for this research is whether there is a correlation between accessibility and usability, and this stage will basically support or negate the hypothesis. This will be done by comparing the ranked list of accessible websites with the ranked list of usable websites and examine whether there is a common pattern in the two lists.

Chapter 3: Accessibility and Usability Frameworks

Accessibility Framework:

From the website audit reports prepared by MADA, it's noticeable that some of the accessibility checklist items have higher priorities than others. For example, websites in Qatar should have a language HTML tag to detect the Arabic language (and other languages as well). MADA gives the language check a higher priority than linkable ALT text images. This difference is because if a screen reader doesn't identify which language is used, this will limit a disabled person's use of the whole site, especially if the person is blind. If a user does not understand the language of the website, regardless of the accessibility status of the rest of the site, the content will not be accessible by the disabled person.

Therefore, when assessing and comparing the accessibility status of websites, such priorities should be take into consideration so as to have a mathematically accurate score to evaluate and compare different websites.

With the use of multi-attribute utility theory, website ranking will be based on a quantifiable method that follows these steps (Liu, 2012):

> **Step 1:** Define and rate each attribute on a 5-point scale scored from best (100) to worst (0) that reflects its priority (see example of CMUQ website, Table 4). In other words, for each website, how well each alternative does on each element should be identified with a score (s) on a scale from 0-100.

Table 4: Ratings of accessiblity elements on a scale from 0-100 for CMUQ website

Element Checklist	Score (s)
Language	100
Color contrast is below the minimum ratio of 4.5:1	75
Use of tables for webpage layout	50
Missing ALT text for linkable images	75
Nested heading elements	25
Other elements	50

Step 2: Scale and normalize attribute scores in terms of each attribute's best-to-worst range; this will result in a proportion somewhere between 0 and 1 for each attribute. The general formula that can be used is

$$Ui \; \frac{x - Worst}{Best - \text{Worst}}$$

Where "worst" refers to the criterion with the least favorable score and "best" refers to the criterion with the most favorable score.

Step 3: Weight the attributes to reflect users' preferences about the relative importance of each attribute (See Table 5).

Table 5: Weight of accessibility elements to add up to 1.0

Element Checklist	Weights (w)
Language	0.3
Color contrast is below the minimum ratio of 4.5:1	0.2

Use of tables for webpage layout	0.1
Missing ALT text for linkable images	0.1
Nested heading elements	0.1
Other elements	0.2

Step 4: Calculate the overall multi-attribute score

Finally, each element's score will be multiplied by the weight given to that element, and the total value (v) calculated ($v = \Sigma ws$). This total will represent the accessibility assessment of the website. Then, all websites can be compared according to the same calculation.

The table below (Table 6) will be completed for each website to get the final value that represents the accessibility status score of the website.

Table 6: Formula to calculate the total value of a website. This will be calculated for each website.

Element Checklist	**Weights (w)**	**Normalized Score (Ui)**	**Element value (w* Ui)**	**Total Value (v =** Σw Ui**)**
Language	0.3			
Color contrast is below the minimum ratio of 4.5:1	0.2			
Use of tables for webpage layout	0.1			
Missing ALT text for linkable images	0.1			
Nested heading elements	0.1			
Other elements	0.2			

Usability Framework:

Website usability depends on many factors and criteria as presented in the QUIM model. To measure and determine a website's usability status, each and every factor and criteria presented in the QUIM model should be measured. This framework is intended to reduce the complexity of the website usability testing procedure by providing fewer figures (numbers) for the assessment. To produce the framework, a list of questions was created, with each question measuring a specific criterion in QUIM.

Because the purpose of the QUIM model is to measure software usability, some of its criteria, such as resource safety and insurance, do not apply specifically to a website. Some criteria such as readability and loading time could be measured automatically using online tools (e.g., Sitebeam and Gtmetrix). And some criteria such as privacy (whether users' personal information is appropriately protected) and flexibility (whether the user interface can accommodate a user's personal preferences) could be measured manually (e.g., by a researcher or Web developer).

- Attractiveness: This relates to the capability of the software product to be attractive to the user (e.g., through use of color or graphic design; ISO/IEC 9126-1, 2001) (Seffah, Donyaee, & Klein, 2006).

Website attractiveness mainly depends on visual design (e.g., use of different media) and content (Sutcliffe, 2001). Sutcliffe (2001) proposed specific heuristics for evaluating the attractiveness and aesthetic design of websites. Based on these seven heuristics, the following scale was created to measure website attractiveness:

Task: Take a few seconds to look around the homepage of the website

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

The use of colors is balanced in the page

The page layout is structured and symmetrical

The background color/image is eye-catching

Media (photos, videos, and audio) are well used

The website contains imaginative images

- Self-descriptiveness: Capability of the software product to convey its purpose and give clear user assistance in its operation (Seffah, Donyaee, & Klein, 2006).

Task: Take few seconds and look at the website.

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

I know the purpose of the website

I know what I can find/do in this website

- Flexibility: Whether the user interface of the software product can be tailored to accommodate a user's personal preferences (Seffah, Donyaee, & Klein, 2006).

Task 1: Open website in different device sizes (PC, tablet, mobile phone)

Measure: Could be tested by researcher on mobile, tablet, and desktop view

Task 2: Take a look at the homepage of the website

Measure 2: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

Users are able to customize/manipulate website interface (colors, placement of content)

Website provides user selection of data for display

Website handles user-specified screen size

Website is available in two or more languages

- Minimal action: Capability of the software product to help users perform their tasks with a

minimum number of steps (Seffah, Donyaee, & Klein, 2006).

Task: Find course/class schedule for spring 2014

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

Website provides global search

Website requires minimal steps in sequential menu selection

The return to higher-level menus require one simple key action

The return to the general menu requires one simple key action

The required data will be entered only once

Form provides default values

- Minimal memory load: Whether the user is required to keep a minimal amount of information in mind to achieve a specific task (Seffah, Donyaee, & Klein, 2006).

Task: Imagine you are applying for this school/university, find the admissions form and fill it in. Do not hit "Submit"

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

Abbreviations and acronyms are well used across the website

Guidance information is always available

Hierarchic menus are provided for sequential selection

Selected items are highlighted

Website provides an indicator of current position in menu structure

Supplementary verbal labels are provided for icons

Long data items are partitioned

Prior answers are recapitulated

- User Guidance: Whether the user interface provides context-sensitive help and meaningful feedback when errors occur (Seffah, Donyaee, & Klein, 2006).

Task: Find the "Contact Us" form fill in the "Comments" box, and click submit.

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

Error messages are informative

System provides "Cancel" option

System provides "Help" option

System provides "Clear" or "Restart" option

Completion of process is indicated

Repeated errors are indicated

- Completeness: Whether a user can complete a specified task (Seffah, Donyaee, & Klein, 2006).

Task: Find information about the curriculum taught in any major of your choice.

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

I was able to complete the task successfully

I have all the information I need about the major curriculum

Most of information/tasks related to this university/school can be completed via the website

- **Operability**: Amount of effort necessary to operate and control a software product (Seffah, Donyaee, & Klein, 2006).

Task: After exploring the website and performing all the different tasks rate as appropriate

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the

following:

I was able to complete all tasks without guidance

I was able to complete all tasks in a short amount of time

- **Consistency**: Degree of uniformity among elements of user interface and whether they offer meaningful metaphors to users (Seffah, Donyaee, & Klein, 2006).

Task: After exploring the website and performing all the different tasks, rate as appropriate

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

The assignment of color codes is conventional

Displays and menu coding is consistent across the website

Label format is consistent

Label location is consistent

Wording is consistent across website

Data display is consistent with user conventions

Graphic data symbols are standard

- Navigability: Whether users can move around in the application efficiently.

Many studies have shown that users navigate through websites in different ways based on their preferences (McGovern & Norton, 2002). Many researchers believe that website navigation strength depends mainly on how quickly users can find the information they are looking for (McGovern & Norton, 2002) (Zhang, Zhu, Greenwood, 2004). Zhang, Zhu, and Greenwood (2004) prepared a questionnaire based on eight different aspects of Web navigability (Zhang, Zhu, Greenwood, 2004) (McGovern & Norton, 2002).

Task: After exploring the website and performing all the different tasks, rate as appropriate

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

It is easy to identify where I am in the website

Navigational elements are similar to other websites

Global navigations are on every page

Linked logos on every page of the website

Footers on every page of the website

Links labeled with anchor text that provides a clear indication of where they lead

Clickable items stylistically indicate that they are clickable

A logical site map is available OR a keyword-based search feature is available

The number of clicks it takes to reach a page within the site is minimal

A response occurs immediately (0.1 seconds) after a click is made on a hyperlink

Contact links are present on every page

Help information is present for complex tasks

- Likability: User's perception, feelings, and opinions of the product (Seffah, Donyaee, & Klein, 2006).

In other studies, the definition of likability was also used to define the term "satisfaction" (Rubin, 1994). According to Rubin (1994), people tend to perform their tasks much better when they are satisfied with a product than when they are dissatisfied. Many researchers have developed questionnaires and methods to assess users' general satisfaction with a product. However, the Questionnaire for User Interface Satisfaction (QUIS) focuses more on users' evaluations of the

interface (Chin, Diehl, & Norman, 1988). Most websites use QUIS as part of the usability testing process, and it is licensed to 76 websites (Harper & Norman, 1993).

Some questions were removed or edited, because they either did not relate to websites specifically or the topic was already covered in other similar criterion.

Task: After exploring the website and performing all the different tasks, rate as appropriate

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

Overall reaction to the website is wonderful

Highlighted content simplifies tasks

Organization of information is clear

Sequence of content displayed is clear

Position of content on screen is consistent

Performing tasks is straightforward

Website is reliable

- Familiarity: Whether the user interface offers recognizable elements and interactions that can be understood by the user (Seffah, Donyaee, & Klein, 2006).

Previous studies about usability define familiarity as the knowledge people have of a website based on their previous interactions and experience (Flavián, Guinalíu & Gurrea, 2006). Flavián, Guinalíu & Gurrea (2006) in their research about the role of experience used a questionnaire to measure three variables: familiarity, usability, and loyalty. For the purposes of this research, only three questions related to familiarity will be used from Flavián, Guinalíu & Gurrea (2006) research.

Task: After exploring the website and performing all the different tasks, rate as appropriate

Measure: Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following:

The website elements can be understood

I am quite familiar with this website

In comparison with other websites, the website interface is recognizable

Compared with the typical user of this website, I believe I am quite familiar with it.

By researcher:

- Privacy: Whether users' personal information is appropriately protected (Seffah, Donyaee, & Klein, 2006).

Task: Make sure privacy policies are provided in the website

Measure: Yes or No

- Load time: Time required for a Web page to load (Seffah, Donyaee, & Klein, 2006).

Task: Copy and paste website link in GTmetrix online tool

Measure: Time in seconds

Doesn't apply to websites:

- Resource Safety

- Insurance

After looking into how each criterion is assessed, a list of 65 questions was produced. Some of the questions are Likert scale question (scale of 0 = strongly disagree to 5 = strongly agree) and others are polar questions (yes or no answers). In the process of putting these questions together, some questions were used to assess more than one criterion. In other words, some of the criteria are interrelated and relevant to each other. To be more accurate about which criteria are relevant and the strength of the relevance, the correlations between these questions need to be identified by user data input to each of the questions.

Then, principal components analysis (PCA) needs to be performed to combine the correlated different criteria and reduce the number of variables used in assessing usability. PCA is a statistical method used to identify and combine sets of correlated observations variables to reduce dimensionality (criteria), to help in visualizing and comparing variables, and to analyze exploratory data (Kramer, 1991).

Chapter 4: Future Work and Conclusions

There are several research directions that can be pursued to develop a greater contribution to the Web development and design field.

Research Direction 1: Complete Usability Framework

A unified framework to assess website usability needs to be created to give a more convenient test of websites' usability status. The current frameworks either decompose different factors and criteria of usability into a model (i.e., QUIM (Seffah et al., 2006)) or they provide measures for part of these criteria (Lin et al., 1997). It would be preferable that a framework for *quantifying* these different components be suggested. Because this research already formed a questionnaire (consisting of 65 questions) to evaluate each criterion, the next step would be to measure them. Using Principal Component Analysis (PCA), these 65 variables (questions) can be reduced to fewer variables to deal with while producing the framework. Principal Component Analysis can be applied through the following steps (Jordan, 2011):

Step 1: Get collected data in a spreadsheet in which each row is a participant response and each column is a variable (criteria).

Step 2: The collected data will be in different forms; some in a Likert scale from 0-5 and some are yes or no answers (1 and 0). These data need to be adjusted and normalized in the same way so that each column has a mean of 0 and a standard deviation of 1.

Step 3: For each row (response), the 65 columns (correlated variables) need to be reduced into bundles of columns, uncorrelated variables, by finding which columns are most important and have the biggest impacts as well as finding which columns have correlations between them. This will create a simplified data set. Then software (e.g., MATLAB) would use a built-in function to return a matrix of all responses (rows) and the new uncorrelated variables (columns).

Step 4: Calculate new scores for each column (response).

After performing the PCA, we are left with fewer variables to be used for usability assessment. These usability variables can be combined into a mathematical formula/framework that gives out one value that yields a website usability score.

This new framework will be used to assess the usability of each of the 25 websites, resulting in 25 usability scores. These scores will allow websites to be compared in terms of usability status. These usability scores can then be ranked to list websites from most to least usable.

Research Direction 2: Correlation between Accessibility and Usability

Another research direction is to find the correlation between the two qualities of a website, accessibility, and usability. The ranked lists of accessible and usable websites can be compared to see if there is any relation between the scores. Finding whether there is a correlation will either support or negate the hypothesis of this research (accessible websites are more usable).

Research Direction 3: Usability Assessment Interface

A Web application can be developed to automatically calculate the usability score of a website. Similar to accessibility assessment, a website usability assessment can be turned into a much easier process for Web developers and designers. The Web app could be a simple automated tool that lets users enter a website link and within seconds calculates a usability score. The mathematical calculations and analysis of each criterion can be programmed in the backend of the application. Therefore, Web developers and designers will be more efficient in performing website usability assessments.

Conclusion

The aim of this thesis has been to develop a deeper understanding of two important qualities of websites: accessiblity and usability. Another goal was to develop a usability assessment framework that combines different factors affecting our judgment of usability status. Chapter 1 presented a background study around accessiblity and usabilitiy. First, it presented how the W3C initiated Web accessiblity recognition internationally in 1997. The initiative resulted in a set of standards and guidelines that aimed to ensure online content accessiblity by all users, abled and disabled (physically and mentally). The different standards and guidelines were then discussed. The WAI, which is a part of W3C, published WCAG 1.0 as the first version of the international guidelines. In 2008, this version was updated and modified to WCAG 2.0, which is the second version of the guidelines. WCAG 2.0 contains 17 guidelines and three priority checklists and it is now recognized as the official international standard for website accessibility. In Qatar specifically, the Assistive Technology Center, MADA, worked to develop a policy that aims to raise the e-accessibility level across all digital platforms in the country. According to the policy, all websites in Qatar should follow Web Content Accessibility Guidelines (WCAG) 2.0 to ensure online accessibility.

The literature review also discussed the different definitions of the term usability. Various organizations, such as the ISO, the IEEE, and the Nielson Usability Consultant Group defined usability differently. According to Nielson (2003), usability is “a quality attribute that assesses how easy user interfaces are to use.” Usability has many standards, and many organizations have worked to develop standards and guidelines for usability assessment.

However, there is no one inclusive guidelines for usability that is being followed internationally. The most prominent guidelines in usability assessment are ISO 9241-11 (1998) (ISO 9241-11,

1998) and Health and Human Services (HHS) (U.S. Department of Health and Human Services, 2006).

After this background discussion, the proposed hypothesis states, “accessible websites are more usable.” To support this hypothesis, a five-step methodology was partially followed. Chapters 2 and 3 explained each step of the research methodology. The steps are:

1- Choosing websites: This step involves selecting educational websites to act as case studies for this research. The chosen websites are all from the educational sector and include a mix of universities and schools.

2- Accessibility Assessment: In this step, an accessibility assessment of each website was conducted using two automated tools, WAVE and Colour Contrast Analyzer. Then, to have an accurate mathematical comparison of the different websites performance on accessibility, an accessibility framework was produced. Using Multi-Attribute Utility Theory (MAUT), the framework was produced based on a subjective prioritization of the most important elements of website accessibility, according to MADA auditing reports. The five most important elements are: Language, color contrast is below the minimum ratio of 4.5:1, use of tables for webpage layout, missing ALT text for linkable images, and nested heading elements.

   Using the assessment scores, the websites were ranked from most to least accessible.

3- Usability Framework: This step involved heavy research into how usability is assessed. All the research agreed that many factors need to be considered when measuring usability. Furthermore, a research paper by Seffah, Donyaee, & Klein (2006) decomposed 10 usability factors and 26 criteria into a one consolidated model (QUIM). The QUIM model does not provide ways to measure each of the criterion, and it is concerned with product

usability, not specifically website usability. This research used the QUIM model to develop a framework that meaures these criteria in the context of website usability.
A big portion of this research was devoted to creating a questionaire to measure each criterion. The questionnaire resulted in 65 questions (a mix of Likert scale questions and yes/no questions).

4- Usability Assessment: The purpose of this step would be to use the produced framework to assess the 25 websites. The assessment would be followed by preparing a ranked list of the websites from most to least usable.
5- Finding correlations: This final step of the methodology would support or negate the hypothesis by determining whether there is any relation between accessibility and usability.

In Chapter 4, this thesis proposed some areas of further research and improvements to have a greater contribution to the field. The fourth chapter presented instructions on how to produce a usability framework by using PCA. This analysis converts and reduces large sets of correlated variables into fewer variables to make data easier to deal with. The new variables could then be used to form the usability framework. The 25 websites would be assessed using the framework that was produced.
The chapter also indicated how the correlation between accessibility and usability could be found by comparing both ranked lists.
Finally, an automated online tool for usability assessment was proposed as an extension to this thesis. This tool would make a radical impact on Web developers and designers as they perform usability testing.

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Appendix

Appendix A: Usability Assessment

Criteria	Questions	Question Score	Criteria Totals
Task: Take a few seconds to look around the homepage of the website. Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements			
Attractiveness: Is the software product capable of being attractive to the user (e.g., through use of color or graphic design; ISO/IEC 9126-1, 2001) (Seffah, Donyaee, & Klein, 2006).	The use of colors is balanced in the page		
	The page layout is structured and symmetrical		
	The background color/image is eye-catching		
	Media (photos, videos, and audio) is well used		
	The website contained imaginative images		
Task: Take few seconds and look at the website. Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements			
Self-descriptiveness: Capability of the software product to convey its purpose and give clear user assistance in its operation (Seffah, Donyaee, & Klein, 2006).	I know the purpose of the website		
	I know what I can find/do in this website		
Task: Take a look at the homepage of the website. Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements **Researcher Only: Open the website in different device sizes (PC, tablet, mobile phone). Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements			
Flexibility: Whether the user interface of the software product can be tailored to accommodate a user's personal preferences (Seffah, Donyaee, & Klein, 2006).	Users are able to customize/manipulate website interface (colors, placement of content)		
	Website provides user selection of data for display		
	Website handles user-specified screen size		
	Website is available in two or more languages		
	**Website has responsive design		
Task: Find a course/class schedule for spring 2014. Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements			
Minimal action: Capability of the software product to help users achieve their tasks in a minimum	Website provides global search		
	Website requires minimal steps in sequential menu selection		

number of steps (Seffah, Donyaee, & Klein, 2006).	The return to higher-level menus requires one simple key action		
	The return to the general menu requires one simple key action		
Task: Imagine you are applying to this school/university, find the admissions form and fill it in. Do not hit "Submit." Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements			
Minimal memory load: Whether the user is required to keep a minimal amount of information in mind to achieve a specific task (Seffah, Donyaee, & Klein, 2006).	Abbreviations and acronyms are well used across the website		
	Guidance information is always available		
	Hierarchic menus are provided for sequential selection		
	Selected items are highlighted		
	Website provides an indicator of current position in menu structure		
	Supplementary verbal labels are provided for icons		
Task: find the "Contact Us" form, fill in the "Comments" box, and click submit. Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements			
User Guidance: Whether the user interface provides context-sensitive help and meaningful feedback when errors occur (Seffah, Donyaee, & Klein, 2006).	Error messages are informative		
	System provides "Cancel" option		
	System provides "Help" option		
	System provides "Clear" or "Restart" option		
	Completion of process is indicated		
	Repeated errors are indicated		
Task: Find information about the curriculum taught in any major of your choice. Using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the statements			
Completeness: Whether a user can complete a specified task (Seffah, Donyaee, & Klein, 2006).	I was able to complete the task successfully		
	I have all the information I need about the major curriculum		
	Most of information/tasks related to this university/school can be completed via the website		
Task: After exploring the website and performing all the different tasks, using a scale of 0 = strongly disagree to 5 = strongly agree, please rate the following statements:			
Operability: Amount of effort necessary to operate and control a software product (Seffah, Donyaee, & Klein, 2006).	I was able to complete all tasks without guidance		
	I was able to complete all tasks in short amount of time		
Consistency: Degree of uniformity among elements of user interface	The assignment of color codes is conventional		

and whether they offer meaningful metaphors to users (Seffah, Donyaee, & Klein, 2006).	Displays and menu coding is consistent across the website		
	Label format is consistent		
	Label location is consistent		
	Wording is consistent across website		
	Data display is consistent with user conventions		
	Graphic data symbols are standard		
Navigability: Whether users can move around in the application efficiently (Seffah, Donyaee, & Klein, 2006).	It is easy to identify where I am in the website		
	Navigational elements are similar to the other websites		
	Global navigations are on every page		
	Linked logo on every page of the website		
	Footer on every page of the website		
	Links labeled with anchor text that provides a clear indication of where they lead		
	Clickable items stylistically indicate that they are clickable		
	A logical site map is available OR a keyword-based search feature is available		
	The number of clicks it takes to reach a page within the site is minimal		
	A response occurs immediately (0.1 seconds) after a click on a hyperlink		
	Contact links are present on every page		
	Help information is present for complex tasks		
Likability: User's perception, feelings, and opinions of the product (Rubin, 1994) (Seffah, Donyaee, & Klein, 2006).	Overall reaction to the website is wonderful		
	Highlighted content simplifies task		
	Organization of information is clear		
	Sequence of content displayed is clear		
	Position of content on screen is consistent		
	Performing tasks is straightforward		
	Website is reliable		
Familiarity: Whether the user interface offers recognizable elements and interactions that can be understood by the user (Seffah,	The website elements can be understood		
	I am quite familiar with this website		

Donyaee, & Klein, 2006).	In comparison with other websites, the website interface is recognizable		
	Compared with the typical user of this website, I believe I am quite familiar with it.		
By researcher, manually and automatically using an online tool.			
Privacy: Whether users' personal information is appropriately protected (Seffah, Donyaee, & Klein, 2006).	Is a privacy policy provided in the website? (Yes=1, No=0)		
Load time: Time required for a Web page to load (Seffah, Donyaee, & Klein, 2006).	GTmetrix		